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ARTICLES

PROGRESS REPORT ON MOSQUITO ECOLOGICAL STUDIES IN CALIFORNIA *

Compiled by

G. EDWIN WASHBURN, Manager, Turlock Mosquito Abatement District

The California Mosquito Control Association has taken positive action in developing and promoting an effective program of biological investigations of mosquitoes in California since 1950. This action was taken through the "Operational Investigations Committee," which was made up of the following members: G. Edwin Washburn, Turlock Mosquito Abatement District, Chairman; Gordon F. Smith, Kern Mosquito Abatement District; C. Donald Grant, Pulgas-Three Cities Mosquito Abatement District; W. Donald Murray, Delta Mosquito Abatement District; E. Chester Robinson, East Side Mosquito Abatement District; Embree G. Mezger, Solano County Mosquito Abatement District; Herbert P. Herms, Sutter-Yuba Mosquito Abatement District; John N. Belkin, Assistant Professor of Entomology, University of California at Los Angeles.

Through cooperative agreements between the Bureau of Vector Control and the several Mosquito Abatement Districts, $25,000.00 has been set aside to conduct these investigations in subvented mosquito abatement districts each year. These funds were granted to the following units for studies in 1951:

1. The Central Valley Mosquito Ecology Study on Irrigated Pastures; working out of the State of California Vector Control Field Station at Fresno, California; with the Fresno Mosquito Abatement District as the administrative entity.

(a) As a sub-project to the above: an *Aedes* Flight Range Study was carried on in Kern County, California, with the Kern Mosquito Abatement District cooperating.

(b) A continuation of the *Aedes nigromaculis* (Ludlow) embryological studies were carried out at the College of the Pacific in Stockton, California.

2. The Insecticide and Toxicological Studies with the Kern Mosquito Abatement District as the administrative entity.

3. The Rice Field Mosquito Investigations with the Sutter-Yuba Mosquito Abatement District as the administrative entity.

Excerpts and notes from the individual reports which came from these studies follow.

1. A COOPERATIVE ECOLOGICAL STUDY OF IRRIGATED PASTURES, by R. C. Husbands.

When the project in mosquito ecology was first established the problems were well defined. The problems are: The great increase in the amount of land being irrigated as a result of the development of the Central Valley Project, the increasing problems of maintaining the standards of mosquito control in California, the new public health aspects of present control practices, and a complete lack of knowledge about the natural history of pasture mosquitoes.

* Although this is a "Proceedings Paper," it was not received in form for publication until too late to be included with the other AMCA Proceedings papers in the first two numbers of MOSQUITO NEWS following the AMCA meetings in Salt Lake City in March, 1952. Therefore, and since the individual papers of the compilation have already been published in full in the Proceedings of the 20th Annual Conference of the California Mosquito Control Association, the present paper will only call attention to the individual contributions, with notes and excerpts to show their contents.—Editor's Note.

With these problems in mind the project set up specific objectives. Fundamentals were to come first, followed by the more complex aspects of mosquito ecology such as the interaction of various factors, the investigations of mosquito behavior, and the studies of mosquito ova. Objectives selected in the original program were outlined as follows:

1. The significance of *Aedes nigromaculis* (Ludlow) and *Aedes dorsalis* (Meig.) in regard to encephalitis.

2. The seasonal comparisons of the life cycles of species of pasture mosquitoes.

3. The influence of pasture fauna, soil, flora, and irrigation practices upon mosquito populations.

4. The influence of other environmental and biological factors upon the natural history of mosquitoes produced in pastures.

5. The evaluation of all biological material to assist in present and future mosquito control.

Maps and photographs were used to measure and record the amount and distribution of water on the fields. Selected stations were located, marked, and visited regularly to give a continuous record of pasture activities. Laboratory studies guided and confirmed the field data. Details on these and other studies are contained in the California Association Proceedings above cited.

2. EMBRYOLOGICAL INVESTIGATIONS OF *Aedes* MOSQUITOES, by John R. Arnold and Gilbert F. Jones.

The objectives of this study were to determine the exact conditions, chemical, biological, and physical, governing the development of the egg of *A. nigromaculis* and to investigate certain factors causing the arrest of continued development of this mosquito from the time of fertilization to the time of hatching.

The development of the ovum of *Aedes nigromaculis* was studied and described in detail. A series of preserved eggs that had developed to the different egg stages under known conditions was collected but a more effective series is to be made when the techniques for sectioning have been perfected.

An important phase of the embryological study on mosquito eggs has been its direct application to problems in field ecology. In determining the length of time that it takes for a complete cycle of development to take place, from egg to egg, the rate of embryonic development must be considered. If there are indications of dormancy in eggs the embryological approach will help us to understand the action and to analyze the methods of using this factor to set up possible control procedures.

3. FLIGHT STUDY ON *Aedes nigromaculis*, by Gordon F. Smith.

The primary objectives of the *Aedes* flight studies in 1951 were an attempt to prove the basic pattern, developed during 1950, through the use of tagged adults; and to further develop and investigate the ramifications of this pattern.

Since the Central Valley Mosquito Ecology Study Unit (C.V.M.E.S.) located in Fresno, California was experienced in the use of tagging agents and flight range is considered to be a basic ecological problem in mosquito control, this unit participated with the Kern Mosquito Abatement District in the study. In their study at Turlock in 1950 they had been able to demonstrate an *Aedes* flight range of only 1½ miles which is extremely short in view of general field experience. The flight studies conducted during 1950 at Turlock were within the Turlock Mosquito Abatement District boundaries and were, therefore, subject to certain limiting factors. The studies of 1951 were conducted in Kern County outside the boundaries of the Kern Mosquito Abatement District and hence were not subject to the limitations of 1950. It was felt that this latter area which was on a larger scale, with the field information on hand in this area, might give more satisfactory results.

Two methods of tagging were proposed. One, the use of radioactive phosphorus and the other the use of Rhodamine "B" dye. It was decided that, all factors considered, radioactive phosphorus tagging should be the primary method used.

An examination of the data shows sev-

eral interesting features. It is apparent that *A. nigromaculis* and *A. dorsalis* do not move or are not moved great distances (unless special conditions are present to initiate this process). Similar work on other species of migratory mosquitoes suggests that recoveries should have been expected with tagged specimens if actual migration had taken place. Further work along this line should be examined carefully before proceeding to general conclusions.

4. Insecticide and Toxicological Investigations, by Lewis W. Isaak.

This report is a summation of the toxicological project which was carried out under the direct supervision of the Kern Mosquito Abatement District. Most of the work completed was done on *Culex* larvae rather than *Aedes*. The reasons for this preference are: (1) C. M. Gjullin of the Bureau of Entomology and Plant Quarantine concentrated on *Aedes* in his resistance studies in the San Joaquin Valley during the summer of 1951. (2) The seemingly sudden increase of extreme resistance encountered with *Culex* larvae at the several duck clubs in the Kern Mosquito Abatement District. This resistance to the chlorinates has reached proportions far beyond all previous estimates.

Twelve larvicides have now been screened using *Culex quinquefasciatus*, Say. Of these tested, EPN was the most effective, followed by parathion, aldrin, colloidal aldrin, heptachlor, dieldrin, DDD, DDT, Q–137, chlordane, lindane, and toxaphene, in that order.

Field testing of colloidal compounds has proved them to be superior to the emulsions as a residual larvicide in permanent ponds. One fresh water pond, treated at .075 lb. per acre of colloidal aldrin was kept free of larvae for 73 days during the warmest summer months of June to September. In highly polluted water, however, these compounds appear to be of little value as a residual larvicide.

Screening completed at the Fresno Field Station consisted mostly of obtaining basic information on *Aedes nigromaculis* larvae from an unsprayed area. Insecticides screened were DDT, toxaphene, Q–137, lindane, aldrin and heptachlor. In addition to the unsprayed area, larvae were collected from one field inside the Consolidated District. It was of interest to note that while neither Q–137 nor lindane had ever been sprayed on that field, the larvae were as relatively resistant to these compounds as to the DDT and toxaphene, the two larvicides which had been used in that area frequently.

Preliminary screening was completed with larvae collected from various duck clubs in the Kern area which had previously proved to be resistant to the chlorinates as applied by regular field applications. This extreme resistance as determined by laboratory analysis and field observations, might be explained by the fact that excessive amounts of various chlorinates were applied to an already resistant strain of larvae, thus killing off all the moderately resistant and non-resistant individuals leaving a residue of highly resistant mosquitoes. It was this remaining group which was brought back to the laboratory for screening; running the degree of resistance into staggering proportions. When it was evident that applications of the chlorinates was of no avail, spraying of these resistant ponds was discontinued.

While EPN has proven to be the most effective insecticide so far used and tested, it should not be used in any manner without close cooperation of the manufacturer and regulatory officials.

5. Rice Field Mosquito Studies, by Robert H. Soroker.

Due to a rather rapid change in personnel this project suffered from a lack of continued guidance by one plan or policy. However, in spite of its many handicaps important advances have been made in the ecological studies of *Anopheles freeborni* Aitken and *Culex tarsalis* Coq. Most of the studies have been concentrated on the ecology and biology of *A. freeborni*. Particular attention has been given to the behavior of the adults and their microclimate. Careful observations have shown

that there is a heavy concentration of adult *A. freeborni* at the margins of the rice checks and banks of ditches, as contrasted to the interior of the checks and ditches. This finding may have real significance in a control program.

Efforts to control *A. freeborni* breeding in the rice growing areas of California by an intensive early spring larviciding program have not been outstanding. In fact, it can safely be stated that this plan cannot be relied upon to give a satisfactory control.

CONCLUSION

It is not expected that all of the biological principles learned through these studies will have immediate field application. Many will only lead to further research. All persons engaged in long range mosquito control activities have come to realize that biological investigations have a prominent place in the mosquito control program, and it is with a look toward the future of mosquito control in California that these cooperative studies are being continued.

RECENT DEVELOPMENTS IN THE CONTROL OF RICE FIELD MOSQUITOES IN CALIFORNIA

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The rice field mosquito problem in California is actually a combination of three separate problems, all of them expensive and complex for mosquito abatement districts. Control involves three of the principal genera of mosquitoes—*Aedes, Anopheles* and *Culex*—an all-year problem intensified during the warm months of the year when rice fields are under water.

Two of the mosquito species are disease vectors: *Anopheles freeborni* of malaria, and *Culex tarsalis* of encephalitis. But actually we are concerned with more than a vector problem, serious as this is. Mosquito abatement districts in the rice growing sections of California must not only keep the mosquito population below the disease level, but they must reduce mosquitoes to a point that will satisfy the demands of the tax-paying public.

Rice acreage in California amounts to about 300,000 acres, most of it in the warm, dry northern part of the Sacramento Valley. Of this, more than 100,000 acres are outside of mosquito abatement districts. An increase in the mosquito problem has accompanied the increase in rice acreage.

Most rice is sowed by plane on land that is already flooded. Fields are flooded just before sowing, and the first major control problem occurs when they are first flooded. This initial flooding hatches eggs of *Aedes dorsalis* and *A. nigromaculis* which have been laid a year or more before. In late May and early June, *Culex tarsalis* larvae appear in quantity around the outside borders of fields and even within some fields. *Culex* adults are numerous by the middle and end of June and continue into the fall. The anophelines reach the adult peak in August and September with all aquatic stages of *Anopheles freeborni* in rice fields at this time. From late June until they are drained rice fields become generally infested by larvae of *Culex* and *Anopheles.*

Fortunately, the *Aedes* problem has been a matter of controlling only the one generation early in the spring. Although only one *Aedes* generation appears in any one field, the problem is complicated because *Aedes* larvae may appear in hundreds of acres of rice flooding at the same time and

all requiring immediate control. In the past, control has been tedious, costly, and not always effective. Men with back pumps walked the winding levees and sprayed all the water they could reach. This method took so much time that only a small acreage could be covered, and many fields had to be neglected.

Another disadvantage became apparent in the slow flooding fields that might require several treatments before they were completely flooded—adults were emerging at the high end while the low end was not yet flooded. Another method that has been tried, and is still useful on a small scale at least, is the dispenser method of injecting a concentrated emulsifiable insecticide at the pump or main head gate or even at each irrigation box. This method distributes the insecticide through the field satisfactorily but is expensive.

As a quicker, more effective and cheaper means of control, the Sutter-Yuba district several years ago devised the method of adding 50 per cent DDT wettable powder to each plane load of rice seed. The powder sticks to the rice seed and settles with it into the water. The dosage effective against *Aedes* larvae was determined as one-quarter to one-half pound DDT per acre or one-half to one pound of powder. This amounts to only three to six extra pounds to each plane load of rice, as a plane generally sows about 6 acres a load. Drilled and slow flooding fields must still be treated in other ways.

A variation of this method has been worked out by the Butte County district which has determined that 3 lbs. of powder per acre will kill the tadpole shrimp, a crustacean pest, which causes serious damage during the early stages of rice development. By adding the extra poundage of powder, growers can control the shrimp at the same time as a district controls *Aedes* mosquitoes.

The *Culex* and the *Anopheles* control problems are not approached in quite so clear-cut a fashion as the *Aedes* problem. In some ways the two can be considered together and in other respects they are entirely distinct. Both mosquitoes are vector mosquitoes and therefore a public health problem. The larvae of both species can be found together or in similar places and both species infest rice fields. *Culex tarsalis,* however, is a summer pest while *Anopheles freeborni* is principally bothersome in the fall and late winter.

The *Culex* problem is so widespread that we have had to consider adults a necessary evil and use aerosol equipment almost continually. The first *Culex* larvae in any numbers appear in late May in seepage around the outside of fields. Small ditches near the fields often fill up as the water level in a nearby field is raised. Another *Culex* breeding place is the borrow pits left after border levees are raised. The lack of a complete, clean drain also causes *Culex* trouble. Water with no other place to go spreads around the outside of a field. *Culex* trouble can also develop in fields themselves as early as the first flooding. This is true of fields overgrown with weeds and tules, fields that have low swampy spots, those with grass-covered old levees, and fields with no definite border levee to prevent water from drifting into adjoining weed patches.

Sacramento Valley districts concentrate much of their control work upon seepage areas. Men equipped with back pumps spray the seepage around the outside of fields. Pressure spray rigs on jeeps are also used when possible. However, many places are nearly inaccessible even on foot and a vast amount of territory must be covered in a short time.

To reach the inaccessible but still important larval sources and cover the territory quickly, a dusting airplane has been tried experimentally with some success. The plane applies a very light dosage of DDT wettable powder around the edges of the fields. Weather conditions must be nearly windless for dusting and the plane must often fly high because of obstructions. Dust is preferred to an oil spray which could conceivably cause damage to tender rice shoots lying on the water surface at this time. However, beneficial control work outside a field can be virtually nullified by weed infested fields.

Anopheles freeborni larvae are often found with *Culex tarsalis* larvae but adults are not very noticeable until August and September. Adult females hibernate in various man-made shelters such as buildings, culverts and bridges, and also in natural shelters. The adult females become active with the first warm days in January and February as the temperature rises to about 60° F. or above. Larvae have been found in almost every month of the year but the first instar larvae of the spring brood appear about the end of February or the first of March in rain water ditches and pools. As with the *Culex* problem, fields with weeds and tules usually become infested with anopheline larvae as soon as they are flooded for sowing.

In 1946 the Sutter-Yuba district came into existence and was the first large district (430 square miles) to begin operations in the concentrated rice growing section of the Sacramento Valley. The district's method of dealing with the anopheline rice field problem was patterned after that of the TVA which used a plane equipped with a thermal exhaust aerosol generator. Each load covered more than 400 acres with an aerosol spray which was highly effective against anopheline larvae. Every fall for four years, 20,000 to 30,000 acres of rice were treated in this way.

Although the method was spectacular and economical on a cost per acre basis, it did not serve the purpose; a heavy population of anopheline larvae reappeared within a few days after an apparent 100 per cent control job. Because of the acreage involved, it was too costly to repeat every week or two and the method was abandoned. Adults of both *Culex tarsalis* and *Anopheles freeborni* protected by weeds on the levees and *Culex* larvae were virtually unaffected by the aerosol spray.

A plane with a spray boom is still useful in anopheline control, particularly in the spring, upon long sloughs, shallow lakes, and receding floodwater lakes and lagoons. Butte County uses a plane in the fall to apply a liquid spray at one quart to an acre. It reports good results on its rice fields.

In the last two or three years, some of the districts have been paying more attention to larvae-producing residual water near rice fields. They have taken advantage of the fact that a great deal of beneficial larviciding can be accomplished before rice fields are even flooded—a recommendation first advanced some thirty years ago by Dr. S. B. Freeborn of the University of California.

Such large areas as river bottom lakes, lagoons, and borrow pits may require the use of a plane. Heavy populations of anopheline larvae have been found after floodwaters recede, and although the spring treatment method, which has been adopted by the Sacramento-Yolo and the Sutter-Yuba districts, considerably reduces the population of mosquitoes that infiltrate into rice fields, other conflicting factors must also be considered.

For instance, rice fields are apparently first invaded from some nearby source that may be a mere few feet to a hundred or so feet from a field. Early in the year, near almost any prospective rice field, there exists some tule patch or ditch of shallow water where *Anopheles* larvae can be found. Larviciding or eliminating such a source would seem logical as a control measure for any particular field. But *A. freeborni* is considered to be a long-range flier and thus could invade fields over a wide area and offset this work. However, this is a possibility in control that must be considered and investigated more thoroughly.

Although, from the information given, it is obvious that it is difficult to recommend positive specific control measures, there are certain practices that we believe will greatly reduce the extent of the *Culex* and *Anopheles* problem in and around each rice field. These are as follows:

1. An adequately cleaned and graded drain or drains leading from the field to a free-flowing main drain. The field drains also should be accessible to mosquito control equipment if necessary.

2. Clean and complete cultivation of

each field each spring so that there will be no weed growth within the field at the time of flooding and sowing.

3. New levees each spring clean of weeds at sowing time; resurveying should not be necessary after the first year.

4. A definite border levee to prevent water from spreading into weed patches along the outside edges of a field.

5. A border levee higher than field levees to avoid seepage and loss of water from the field.

6. A graded field without low spots that favor weeds and inhibit rice growth.

7. No unnecessary or unused ditches or borrow pits to hold water near the field—most of these places can be easily filled.

Other possibilities exist such as building the border levee from inside a field to eliminate a ditch or borrow pit on the outside that often fills up with water. The shape of the levees themselves might encourage weed growth so that sharp-sided levees might be preferable.

So far as rice field control problems are concerned, the trend in our thinking is away from complete dependency upon the post-war magic insecticides. We believe we must examine other ways, particularly corrective cultural practices, as a possible solution. Some of the ideas we now have are not necessarily new and many were advanced a long time ago. But they are still sound. More thorough studies of the ecology of rice field mosquitoes can contribute materially to the efficiency of control.

PSOROPHORA CYANESCENS (COQUILLETT) NEW TO THE MOSQUITO FAUNA OF NEW MEXICO[1]

T. E. McNEEL, Sr. Sanitarian (R) AND F. F. FERGUSON, Scientist (R)

Southwest-Lower Mississippi Drainage Basins Office, Little Rock, Arkansas

Items of interest to students of mosquitoes of western United States have been disclosed in light trap data compiled in this office for the use of the Mosquito Control and Allied Problems Work Group of the currently active Arkansas-White-Red River Basins Inter-Agency Committee. The sub-committee on problems relating arthropods to public health in AWR Basins water resources projects has, as one of its functions, the task of gathering mosquito distribution and seasonal density data from areas not previously adequately sampled. Adults of *Psorophora cyanescens* (Coquillett), a vicious biting, temporary pool breeder, common to South Central States, are now reported from Tucumcari, New Mexico (August, 1952). *Culiseta inornata* (Williston), normally considered to be an early spring and late fall mosquito, has been taken in small numbers during each of the summer months (June, July, August and September, 1952) from the Northeast New Mexico-Southeast Colorado area of AWR Basins.

[1] From the Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Georgia.

THE USE OF LINDANE AND DIELDRIN AS MOSQUITO ADULTICIDES IN ALASKA[1]

ROBERT A. HEDEEN AND HUGH L. KEEGAN[2]

INTRODUCTION. This paper is a summary of one of the projects undertaken by members of the Alaska Insect Control Project for 1951. As lindane and dieldrin had not previously been used against Alaskan mosquitoes it was considered advisable to conduct tests to determine the effectiveness of these chemicals. Since mosquitoes have been found capable of developing resistance to DDT it is possible that resistant strains could develop in Alaska if this insecticide is extensively used. Need would then arise for other insecticides that would effectively reduce the great numbers of mosquitoes found in some important areas of Alaska.

Personnel conducting these tests were selected from the 498th Preventive Medicine Company, Brooke Army Medical Center, Fort Sam Houston, Texas. Three officer entomologists and ten enlisted technicians were assigned to the overall project. Two officers and three enlisted men were concerned especially with testing the two above mentioned insecticides.

METHODS. A C-47 aircraft equipped with wing-mounted spray booms was used to disperse the insecticides. This plane was assigned to the Alaskan Air Command and was used in the routine spraying of military bases. The average speed when spraying was 140 miles per hour and the average altitude was 100–150 feet. A swath width of approximately 800 feet was obtained at the above speed and altitude.

Galena, located on the Yukon River in central Alaska, and Umiat, situated approximately 175 miles southeast of Point Barrow on the Colville River, were selected as the locations of the tests. Galena was treated with both lindane and dieldrin and Umiat was treated with lindane only.

Both lindane and dieldrin were applied in the form of 10 per cent emulsion concentrates at the rate of 0.05 lb. of toxicant per acre. Landing counts were made by observing the number of mosquitoes landing on the front of the HBT fatigue uniform during a two-minute period. Two individuals made a count, each counting the mosquitoes landing on the other. Two counts were then tabulated after the two-minute period.

FIELD TESTS WITH LINDANE AND DIELDRIN: 1. *First Lindane Test:* A 10 square mile plot at Galena was sprayed with lindane on 2 July, 1951. A survey indicated the following species of mosquitoes were present at Galena: *Culex territans, Culiseta alaskaensis, Aedes communis, Aedes excrucians, Aedes riparius,* and *Anopheles occidentalis.* The last named species was found only in the larval stage.

Average landing count at Galena during the period of the test was 30. Wind velocity at the time of the spray flight was 2–4 miles per hour. Temperature at the time of spraying was 45 degrees F.

Results of the test are as follows: 2 hrs., 45 min. after treatment, 100 per cent reduction; 12 hrs. after treatment, 93 per cent reduction; 24 hrs. after treatment, 77 per cent reduction.

Rain and high winds prevented further checks.

2. *Dieldrin Test:* Dieldrin was applied to a 10 square mile plot at Galena on 9 July, 1951. Landing counts had been reduced to an average of 15 during the period of this test. It is believed that this reduction was due to the cold and wet weather which prevailed during the test

[1] The authors are indebted to the following personnel of the Alaska Insect Control Project for technical assistance: Lt. L. H. Senn, MSC, SFC E. Q. Calamug; Sgt. J. Ralph Inman; Sgt. Joseph Tupper.

[2] 1st Lt., MSC, USA; Capt., MSC, USA. Department of Preventive Medicine, Medical Field Service School, Brooke Army Medical Center, Ft. Sam Houston, Texas.

and not to any residual lindane action. Wind velocity during the test was 2–3 miles per hour and the temperature was 40 degrees F.

Results of the dieldrin test, in terms of per cent reduction after the time intervals named are as follows: 2 hrs., 85 per cent; 12 hrs., 75 per cent; 24 hrs., 50 per cent; 36 hrs., 76 per cent; 48 hrs., 67 per cent; 72 hrs., 30 per cent.

3. *Second Lindane Test:* A 15 square mile plot at Umiat was treated with lindane on 12 July, 1952. Very high pretreatment counts were obtained, the highest being an estimated 800, and the average 350. This average count prevailed in the control area throughout the test period of 9–15 July. Reductions given represent averages between inner and outer zones of the test plot. The outer zone of the plot was that area within one-half mile of the plot boundaries. Wind velocity during the spray flight was eight miles per hour and the temperature was 50 degrees F.

Species found at Umiat included *Aedes nearcticus, Aedes communis,* and *Aedes* sp. (probably *A. punctor*). No larvae or pupae were found in the many pools, indicating that the single generation of mosquitoes per year had all emerged. Jachowski and Schultz (1948) studied the biologies of mosquitoes at Umiat in 1947 and state that no pupae were found after 5 July.

Results of the test in terms of per cent reduction after the time intervals named are as follows: 15 min., 50 per cent; 5 hrs., 95.5 per cent; 22 hrs., 95 per cent; 43 hrs., 86 per cent; 50 hrs., 82 per cent.

Summary: Field tests with the insecticides lindane and dieldrin were conducted by personnel of the Alaska Insect Control Project during the summer of 1951. Galena, Alaska, was treated with both lindane and dieldrin, and Umiat, Alaska, was sprayed with lindane. Results indicate that a 10 per cent emulsion concentrate of either lindane or dieldrin applied at the rate of 0.05 lb. of toxicant per acre is quite effective as an adulticide for several northern species of mosquitoes for periods of time up to three days.

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MOSQUITO AND MALARIA CONTROL IN TAIWAN (FORMOSA)

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Malaria is the most important endemic disease in Taiwan. It affects the majority of the rural inhabitants occupying about 75 per cent of the total population (7,500,000) of the island. Generally speaking, the hilly regions are hyperendemic, with spleen rate 40–85 per cent and parasite rate 15–40 per cent. The plains have moderate or low endemicity, with spleen rate 10–40 per cent and parasite rate 2–15 per cent. The coast has low endemicity (i.e., is "healthy"), with spleen rate less than 5 per cent and parasite rate less than 2 per cent.

As early as 1909 the control of malaria was started by the Japanese Government which was then occupying Taiwan. In 1913 the order and regulations for malaria control were issued by the government.

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After China took back Taiwan in 1945, DDT was introduced for mosquito control, newer anti-malarial drugs were tested and over one hundred local anti-malaria stations were re-established.

Mosquito and malaria control work done from 1901 to 1951 in Taiwan can be summarized in the following two periods.

I. FIRST PERIOD: 1901–1944 (Work done by the Japanese Government)

A. *Mosquito studies.* The earliest scientific report on anopheline mosquitoes in Taiwan seems to be the one by Kinoshita (1901) who described the occurrence of *A. hyrcanus sinensis.* Up to the end of this period, 16 species of anophelines were reported (Morishita, 1936; Matumoto and Motoura, 1939; and Omori and Noda, 1943). Seven species were reported to be naturally infected with malaria parasites (Anazawa, 1931). The work done during this period was mainly on mosquito survey, with few studies on bionomics such as the *sinensis* density (Katagai, 1931; Koidzumi and Tsuchimochi, 1926), blood meals (Morishita and Katagai, 1938) and time of feeding (Omori, 1942).

B. *Malaria control.* Since 1910 many local anti-malaria stations, each with one technician and microscope, were established in different parts of the island, the number of stations being increased to 185 by 1934 and over 200 by the end of this period. General blood survey was done monthly by these stations, and nearly half of the population of the island was examined each year. Those positive for malaria parasites were treated with quinine. As a result of the establishment of these stations malaria generally decreased in prevalence.

Some other methods were also tried, such as drainage and filling, clearing bushes and grasses around human dwellings, encouraging the use of mosquito nets and fumigation, introducing *Gambusia* in 1911, and transplanting cinchona trees in 1922. However, these measures were not carried out systematically and thoroughly.

During World War II, malaria in Taiwan suddenly increased because of the scarcity of drugs and the evacuation of people from the large cities into the country.

II. SECOND PERIOD: 1945–1951 (Work done by the Chinese Government with the assistance of the Rockefeller Foundation and of the Sino-American Joint Commission on Rural Rehabilitation)

During this period malaria again decreased in prevalence as a result of the widespread use of atabrin freely distributed by the UNRRA, the mosquito control activities by the Taiwan Malaria Institute with the help of the Rockefeller Foundation and the JCRR, and the re-establishment of 144 local anti-malaria stations.

A. *Establishment of the Taiwan Provincial Malaria Research Institute.* In July 1946 R. B. Watson of the Rockefeller Foundation and the writer were asked by the Government to make malaria reconnaissance and to find a suitable field station for malaria studies on the island. Four months later, Chaochow, a small town in southern Taiwan, was selected as the station and training of personnel was started by Dr. Watson and the writer with the financial support of the Rockefeller Foundation. In the following year two branch stations were set up separately at Keelung, northern Taiwan and at Shui-li-keng, central Taiwan. The latter branch was closed in 1948 but resumed its activities in April 1949 at Taichung, central Taiwan. All these stations were officially established in April 1948 as the Taiwan Provincial Malaria Research Institute by the Taiwan Provincial Government.

Unfortunately the Rockefeller Foundation withdrew its support from whole China in September 1949. Since the beginning of 1950 the JCRR has given financial help to the Malaria Institute.

B. *Mosquito studies. Anopheles fluviatilis* was added to, and *A. kochi* was removed from the list of Taiwan anophelines (Chow, 1949). An extensive collection of culicine mosquitoes was first made in Taiwan by Chow (1950).

A. minimus was proved as the impor-

tant vector of malaria (Chow *et al.,* 1950), but *A. hyrcanus sinensis* still needs further confirmation (Chow *et al.,* 1951). As to the other five species reported by Anazawa (1931), they seem not important in malaria transmission in Taiwan. The seasonal prevalence of anophelines in human dwellings, animal stables and ground pits was reported by Chang *et al.* (1950), while detailed study on their resting places in human dwellings was made by Chow *et al.* (1951). Time of feeding, egg-laying behavior, host preference, relation of anopheline breeding and rice cultivation, and other bionomics studies were also in progress.

C. *Malaria control.* (1) Drug control: In order to study the efficacy, optimum dosage and reaction, if any, of the Oriental people to certain newer anti-malarial drugs, field trials of chloroquine (SN–7618–5) and chlorquanide (paludrine) were carried out since 1947 in central and southern Taiwan (Watson *et al.,* 1950, a and b).

(2) DDT larvicide and residual spraying: The results of these experimental controls will be reported in another paper; but it may be noted here that with the help of J. C. Carter of the Rockefeller Foundation these experiments were carried out in southern Taiwan since 1947.

As the common solvents for DDT, such as xylene and kerosene, were expensive and difficult to obtain in quantity, some local materials were searched for this purpose. Camphor oils (brown and white) were found to be satisfactory (Chow *et al.,* 1951, a) and used for making DDT emulsion with Triton X–100 as emulsifier. Paddy fields, which are the main breeding place of *A. hyrcanus sinensis,* were sprayed with DDT emulsion at the rate of 0.05–0.1 lb. of technical DDT per acre of water surface, at intervals of ten days during the crop seasons. Hudson "Industrial" hand sprayers with nozzle "LN 2" of Spraying Systems Co., at discharge rate of 2 gal. per hr., were used. It is worthwhile to mention here that DDT emulsion at the above dosage showed no damage to rice crops.

For indoor residual spraying, 50 per cent wettable powder of DDT was used, and different dosages of 0.5, 1 and 2 gms. of technical DDT per sq. m. surface, twice a year, were tested. The "Clinton" Power Sprayers, Hudson Wheelbarrow sprayers and hand sprayers (both Hudson and Lofstrand) with flat nozzle "8002" were used. No chemical or biological tests of DDT residual effect were done.

(3) Automatic siphons: Five automatic siphons were built with the help of J. C. Carter in five streams at Keelung, northern Taiwan, in July 1948 for controlling *A. minimus* larvae.

(4) Rehabilitation of local anti-malaria stations: In 1950–51 a total of 144 stations have been re-established in different parts of the island. The technicians, who are in charge of these stations and have had good experience on blood examination, were given a refresher course and later on were under the supervision of the appropriate branches of the Malaria Institute. Each station was equipped with one microscope and other supplies, anti-malarial drugs, bicycle, etc. The activities of these stations are to carry out regular blood survey and distribution of anti-malarial drugs to the patients, either in the dispensary or in the field of their own area. It is interesting to mention that these stations are practically supported by the communities they serve.

By the administration of anti-malarial drugs (paludrine and atabrin) to the positive cases examined in these stations, the parasite rate has been reduced from 18.6 per cent among 244,566 people in July–December 1950 to 11.7 per cent among 236,760 people in January–June 1951.

D. *DDT plant.* A DDT plant was established in 1948 in southern Taiwan, now known as the Taiwan Agricultural Chemical Works. The plant is in good condition and its products are of good quality. However, due to lack of a sufficient amount of benzene, only 20 tons of technical DDT have been produced per month. The plant has been producing 10 per cent DDT dust, 5 per cent DDT solution in refined kerosene and 25 per

cent DDT emulsion concentrate in camphor oil, and is making 50 per cent DDT wettable powder.

III. OUTLOOK OF MALARIA CONTROL IN TAIWAN

Based on our studies and experimental control in Taiwan since 1946, it appears that DDT residual spraying is the control method of choice. As to larvicide, it needs strict and constant supervision of the laborers. For paddy field spraying it is very difficult to reach the water surface when the rice plants grow over 80 cm. in height. It is not suitable as the sole method for malaria control in a place where paddy fields occupy an enormous area and form the main breeding place of the mosquito vector.

The mosquito vectors in Taiwan are domestic in habit, and the possibilities of control through limited selective spraying of human dwellings (bedrooms and part of sitting rooms) seem worthwhile to be tested in the field as suggested by Chow *et al.* (1951).

As Taiwan has an excellent foundation on malaria work, a well-developed malaria institute, over one hundred local anti-malaria stations, a large number of trained personnel, good communication and co-operative people, the prospect seems very encouraging of controlling, if not eradicating, malaria from the whole island within a few years. Francisco J. Dy, Malaria Adviser of the Western Pacific Regional Office of the World Health Organization, visited Taiwan in August 1951 to arrange with the government for the sending of a WHO malaria control demonstration team, probably early in 1952, to assist Taiwan in approaching the above-mentioned goal.

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TOXICITY OF EPN, DDT, AND PARATHION TO LARVAE OF VARIOUS SPECIES OF MOSQUITOES

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It is well known that insecticides differ in their effectiveness against various species of insects. As an example, Yates (1951) showed that 0.001 p.p.m. of DDT killed 97 per cent of first-instar floodwater *Aedes* larvae but only 22 per cent of *Aedes dorsalis* (Meig.). Knowledge of the selective action of insecticides on different species of insects is of importance in control efforts.

This paper gives the results of laboratory tests at Corvallis, Oregon with EPN,[1] DDT, and parathion on fourth-instar larvae of floodwater *Aedes* (70 per cent *vexans* (Meig.) and 30 per cent *sticticus* (Meig.)), *Culex quinquefasciatus* Say, and *Culiseta incidens* Thom. The *Aedes* larvae were obtained from soil taken from breeding areas along the Columbia River, the *Culex* larvae were from a laboratory colony, and the *Culiseta* larvae were obtained from egg rafts collected locally. All were reared to the fourth instar at a constant temperature of 80° F. and the larvicide tests were conducted at this temperature. Twenty larvae were used in either 200 or 300 ml. of tap water. Five to six concentrations of DDT and EPN and three to four of parathion were used on each species. Each test was repeated three to eight times. Mortality counts were made at both 24 and 48 hours, and the average mortalities for each concentration were plotted on coordinate paper to obtain the LD-50 and the LD-90 (Table 1).

On the floodwater *Aedes* the concentrations giving LD-50 were similar for all these insecticides although EPN was slightly more toxic. The concentrations required to give LD-90 were still closer together.

With *Culex quinquefasciatus* 31 times as much DDT and almost twice as much parathion as EPN were required to give LD-50. EPN was the most toxic insecticide to mosquito larvae tested at this laboratory.

With *Culiseta* 3.4 times as much DDT and 2.2 times as much parathion as EPN gave LD-50 and LD-90.

Both EPN and parathion were more toxic to *Culex* than to *Aedes* or *Culiseta*, but DDT was the most toxic material to *Aedes*. Thirteen times as much DDT was required to give LD-50 or LD-90 on *Culex* as on *Aedes* and about three times as much as on *Culiseta*. On the other hand, both EPN and parathion required nearly 1.6 times as much poison for LD-50 on *Aedes* than on *Culex*. EPN was less toxic to *Culiseta* than to *Aedes* or *Culex*. On the LD-50 basis parathion was about 1.5 times as toxic to *Aedes* as to *Culiseta*.

TABLE 1. Parts per million of EPN, DDT, and parathion required to give LD-50 and LD-90 to mosquito larvae of several species

Insecticide	Floodwater *Aedes*		*Culex quinquefasciatus*		*Culiseta incidens*	
	LD-50	LD-90	LD-50	LD-90	LD-50	LD-90
EPN	0.00135	0.00342	0.000821	0.00143	0.00196	0.00364
DDT	0.00196	0.00435	0.025	0.05	0.00667	0.0133
Parathion	0.00253	0.00431	0.00158	0.00228	0.00364	0.00793

[1] Ethyl p-nitrophenyl thionobenzene.

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MATING SWARMS OF MALES OF THE MOSQUITO, *AEDES PUNCTOR* (KIRBY), IN ALASKA

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INTRODUCTION. Close observation of seventy-four swarms of male *Aedes punctor* mosquitoes near Auke Bay, Alaska, in 1952 leads us to question the general validity of the conclusion of Nielsen and Greve (1950) that mating and swarming of mosquitoes are unrelated phenomena which normally take place at quite different times. While they observed "several millions of mosquitoes" in swarms during seven seasons they saw only three copulations. Calling attention to the high density of mosquitoes on the ground, they further state that copulation occurs there in the morning or in the air in the afternoon, when there are no swarms of males. However, reviews of the mosquito literature (Howard, Dyar, and Knab, 1913; Wesenberg-Lund, 1920; and Bates, 1949) show virtual unanimity for the thesis that the male swarm is the chief locus for copulation, and that it even provides the essential stimulus. To be sure, many authors comment on the scarcity of mating pairs in the swarms they observed. No workers other than Nielsen and Greve appear to have proposed an explanation for male swarms other than that they are mating swarms. The Danish workers, however, throw out the suggestion "that swarming serves to prevent inbreeding by mixing males from different breeding places." Very recently Nielsen and Nielsen, as reported by Provost (1952), have studied male swarms of *Aedes taeniorhynchus,* the females of which are celebrated migrants. In this instance mixing of males from different breeding places would appear to be superfluous. The Nielsens saw no mating in connection with the swarms they observed near Fort Pierce, Florida. Provost, however, reports mating in the swarms of the same species at Sanibel Island, Florida. The present observations in Alaska do not solve the conflict altogether, but they do show that very high rates of copulation amounting to hundreds or even thousands per evening may occur even in swarms of one of the species studied so assiduously by the Danes. Predation on the swarming male mosquitoes by swarming males of a dance fly, *Rhamphomyia* sp., is also described.

CIRCUMSTANCES. The data were obtained by direct observation, usually with the observer lying flat on the back nearly under the swarm so as to see the mosquitoes against the light of the sunset. The advantage of this position, which was discovered by chance when resting from the arduousness of reclaiming a garden plot, is partly due to the Tyndall effect. The location, a glade in the Tongass National Forest about 15 miles northwest of Juneau, Alaska, sloped westward. While the lay of the land favored evening swarming and observations, morning swarms did not occur.

JUNE SWARMS. The earliest swarms were noted on June 6 at 22:30.† The species was *Aedes punctor,* which is considered to be a forest mosquito, and it is presumed that glades in the gloomy wilderness of western hemlock and Sitka spruce such as the garden clearing are its normal swarming sites. The mosquitoes of the June swarms, however, had doubtless bred in an extensive, open, brackish marsh nearly a mile away in the tidal delta of the Mendenhall River. The actual breeding areas of *punctor* there were shallow depressions in a zone 50–100 yards wide in which a form of the species with reduced, budlike gills occurs at high densities. The eggs hatched from mid-April to mid-May as the melting snow and the tides flooded different areas on the

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† Pacific Standard Time.

flats. Large larvae teemed there the latter half of May, and the first pupae were dipped May 19. During the succeeding two weeks the adults emerging on this open salt marsh migrated into the woods behind.

Large numbers of adults of both sexes appeared June 4 in the tall, dead grass of the garden clearing, and all the June observations were made there. During a vain search for mating activities the following evening the first *Aedes* bite of the season was recorded. Although dissections were not made, it is reasonable to suppose that the clouds of females flying near the ground and showing virtually no blood lust were predominantly composed of virgins until after mid-June. Nevertheless, the number of females seeking blood grew by leaps and bounds during the following week. Counts made on June 11 gave a landing rate of 60–80 (Blanton *et al.*, 1950). Unfortunately the higher rates of the succeeding 10 days, when there was much mating at male swarms, could not be determined by this method; there were too many mosquitoes. The average age of the females, i.e., the proportion of virgins, is possibly the chief difference, other than size of male swarms, between the June swarms in which high rates of copulation were observed, and the July–August swarms where almost no matings were seen. There were ordinarily three swarms each "swarming" evening. They formed at precisely the same locations in the clearing from about 20:30 to about 22:30 on June 6, 10–12, 14–20.

The swarms of June 6 and 10 were large, but unfortunately were not closely observed. No matings were seen. On June 11, however, a casual observation at about 20:45 showed that mating was taking place constantly at high rates at all three swarms. The rates fluctuated between about 25 and 150 matings per minute. Our representative figures give approximations of the order of magnitude of the rate; they were estimated after many trial counts for different periods counting slowly by threes for a minute. The swarms became very large, in numbers of participants, and dense. Not less than several thousand males were in attendance at each. The din of the high-pitched hum could be heard about 40 feet away. When broken up by passing the net through the "core," a swarm reformed within 5–15 seconds. On June 12, the following evening, the same frenzied swarming and copulating took place. No observation could be made June 13, and all subsequent June swarms were smaller, and the average copulation rates, which were easily determined, were only a few per minute or practically zero June 21 and 22.

July–August Swarms. Three weeks after swarming had ceased in the garden clearing, two swarms of mosquito males were discovered about a tenth of a mile away near the shore of Auke Bay. The new swarming sites differed from the earlier ones in the garden clearing in that they occurred under a canopy of branches, and the mosquitoes circled closer to the ground. It was conjectured that another species, then emerging in large numbers, presumably with different swarming requirements was the subject. However, all the genitalia mounts sampled over the ensuing 5 weeks again involved *Aedes punctor,* the species observed in June. In the new swarming loci 36 swarms were observed July 12–15, 17, 19–25, 27–30, August 1–14. They were looser swarms with less than about 75 males participating at once, and the soundness of the term "swarm" for as few as 1–2 males, as suggested by Nielsen and Greve (1950), became apparent from observing the smallest. Swarms formed between 20:30 and 21:00 on clear evenings, but on dark, cloudy nights they sometimes appeared as early as 19:45. They terminated with the sunset about 22:30 in mid-July and progressively earlier until it was about 21:30 in mid-August. Temperatures at which this midsummer swarming occurred averaged about 15 degrees C., ranging from 13 to 18 degrees C. On two evenings following days of heavy rain there was no swarming, but neither was there any on the evening of July 31, one of the bright-

est, warmest days of the year. There were swarms during light drizzles August 2 and 7 and despite a wind of several miles per hour a few other evenings. The summer dipping records showing relatively few *punctor* larvae in the latter half of July and in August suggest the males may have been on the average older than those of the June swarms. It is also not unlikely that relatively few virgin females were on the wing, especially in August.

Whatever the reasons, there was very little mating seen in connection with the July–August swarms. In one and three-quarter hours of attentive watching on July 12, however, two instances were seen, and each of us saw what appeared to be copulating pairs a few times in the succeeding 5 weeks. There may have been low rates proportional to the small size of the swarms which we overlooked. For, unfortunately, the time interval during which a pair of mosquitoes might be clearly visible was short in comparison with the same period for the June swarms. There appears to be no good reason to doubt that mating was of rare occurrence in the summer swarms, nevertheless.

COPULATION. Mating pairs were seen chiefly in the June swarms, only a very few being seen for a part of their nuptial flight in July–August swarms. No instance of mating independent of swarming was found. Thus in our experience the factors favorable to mating are those causing swarming. Representative weather conditions under which swarming occurred ranged from fair and calm to drizzly and windy. The air temperature at the bottom of the swarm where mating pairs initially grappled ranged from 8 to 16 degrees C. However, the very large swarms of June 11 and 12 which had the highest mating rates followed warm, sunny, calm days. The greatest activity of the adults of this species similarly appeared to be at about 15 degrees C.

The act of copulation averaged about half a minute, ranging from ¼ to 1½ minutes. After coming together venter to venter in the lower part of the swarm pairs ascended out of it to a height of 15–50 feet. Ascent became descent when one partner, probably the male, stopped flying and released the claw holds. Pairs came down a variable distance still joined end to end before the terminalia were disengaged and the partners separated. Possibly some reached the ground *in coitu*. This nuptial flight was so regularly observed for all pairs that it would seem unlikely that mating could occur in the species without it (Séguy, 1950). Pairs caught in the net before ascending separated at once. Within the swarm pairs were usually assailed by supernumerary males. Above it, they were frequently seized by male dance flies (cf. following paragraph). Male mosquitoes occasionally grappled momentarily with one another.

DANCE FLY SWARMS. The males of *Rhamphomyia* sp., a species of dance fly (Empididae) swarmed directly above the June male mosquito swarms and preyed upon the males and also on mosquito pairs near the top of the mosquito swarms. These dance flies, first observed June 14, increased in numbers to form conspicuous, loose swarms of about 50 flies each during the week following, while the mosquito swarms became smaller each evening. At first the aggregations of male dance flies over the mosquito swarms were viewed as being there primarily to secure prey, presumably for offering to prospective mates. However, the dance fly males continued swarming after the termination of the mosquito swarming late in June so that it is more reasonable to suppose that the predation was incidental to swarming for some other purpose, presumably mating. The dance flies captured mated pairs of mosquitoes, seemingly preferring them to individual males. They did not depart from their swarming to catch female mosquitoes which were present in high densities in the proximity of the observers. A single instance in which two dance flies engaged at close quarters was regarded as copulation, but this must be viewed as doubtful. It may have been a case of cannibalism involving two males. No females of the dance flies were included in net

collections. Dance flies did not appear in connection with the July–August swarms.

Summary and Conclusions. Seventy-four swarms of *Aedes punctor* males were observed: (A) in June; and (B) in July–August.

(A) The June series of 38 swarms was characterized by large concentrations of hundreds or even thousands of males flying in 3 loci of an open clearing, copulating at the rate of 1–10 per minute or rarely at very high rates estimated at about 150 per minute. A nuptial flight occurred.

(B) The July–August series of 36 small swarms of less than about 75 males each took place evening after evening in two loci under overhanging branches. Very few instances of copulation were seen.

It is concluded that for *Aedes punctor* in Alaska swarming is a behavior closely connected with copulation, i.e., swarms of males are *mating swarms,* but that males form small swarms later in the season which are largely without function since few or no copulations then occur there.

Males of a dance fly (Empididae), *Rhamphomyia* sp., formed swarms above the June mosquito swarms. They also preyed on the mosquito males and pairs.

Acknowledgments. We are indebted to Dr. Alan Stone of the U. S. National Museum who confirmed the identification of *Aedes punctor* by generously examining 50 specimens collected from eight swarms of both series, and to Dr. Willis Wirth of the same institution for determining the dance fly to be a species, "probably new," of *Rhamphomyia.*

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NOTES ON MOSQUITOES IN NORTH AMERICA: II

Collections at Military Installations in Indiana During 1944 and 1945

STANLEY J. CARPENTER [1]

Hart (1944) published records of twenty-four species of mosquitoes found in Indiana. Christensen and Harmston (1944) published a preliminary list of the mosquitoes of Indiana which includes all the species found by Hart and records for five additional species.

This paper includes collection records of twenty-one species of mosquitoes taken during 1944 and 1945 at five military installations located in Indiana. Two species, *Aedes (Aedes) cinereus* Meigen and *Culex (Culex) salinarius* Coquillett, were not reported by either Hart (1944) or Christensen and Harmston (1944). The mosquitoes were collected by Army Medical Service personnel assigned to the

[1] Colonel, MSC, Sixth Army Area Medical Laboratory, Fort Baker, California.

local military establishments and the specimens were forwarded to the Fifth Service Command Medical Laboratory where determinations were made.

The records presented in the following paragraphs include, for each species taken, the months of occurrence, the number of specimens identified, and the localities in which the collections were made, in the order named. The locality name is either the name of the military establishment or the name of the town or city in which the military installation was located. These names are abbreviated as follows: Austin: A; Camp Atterbury: CA; Fort Wayne: FW; Indianapolis: I; Madison: M.

COLLECTION RECORDS

Anopheles barberi, July–Sept., (5), CA, I; *An. punctipennis,* Apr.–Oct., (2167), CA, FW, I, M; *An. quadrimaculatus,* June–Oct., (256), A, CA, FW, I.

Uranotaenia sapphirina, Sept., (24), CA, FW.

Culiseta inornata, Apr.–June, (56), CA, FW, I.

Psorophora ciliata, June 21, 1945, (1), CA; *P. cyanescens,* July 3, 1945, (1), CA; *P. ferox,* June 27, 1945, (3), I; *P. horrida,* July 3, 1945, (3), CA; *P. confinnis,* May 24, 1945, (3), I.

Aedes canadensis, March–May, (992), CA, FW, M; *A. sticticus,* July 3, 16, 1945, (2), CA; *A. trivittatus,* Sept. 20, 1945, (4), CA; *A. triseriatus,* May–July, Sept., (121), CA, FW, I; *A. vexans,* March–Oct., (466), CA, FW, I, M; *A. cinereus,* Apr., June, (30), FW, I.

Culex pipiens, Jan., March–Oct., (1664), A, CA, FW, I; *C. restuans,* Apr.–Oct., (2221), CA, FW, I; *C. salinarius,* May–Oct., (180), CA, FW, I; *C. erraticus,* Aug., Sept., (44), A, CA, I; *C. territans,* Apr.–Oct., (145), CA, FW, I.

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NOTES ON MOSQUITOES IN NORTH AMERICA: III

COLLECTIONS AT MILITARY INSTALLATIONS IN KENTUCKY DURING 1944 AND 1945

STANLEY J. CARPENTER [1]

Dyar (1922) gave locality records for eight species of mosquitoes in Kentucky. Other workers, particularly Quinby (1936, 1937 and 1941) and Quinby *et al.* (1944), contributed much additional information on the mosquito fauna of the State. Quinby *et al.* (1944), cited the earliest known record for each of the forty-two species known to occur in the State and gave their distribution by counties and prevalence. Kitzmiller (1945) reported the occurrence of an additional species, *Orthopodomyia alba* Baker, at Fort Knox, Kentucky.

This paper includes collection records of twenty-four species of mosquitoes taken during 1944 and 1945 at six military installations located in Kentucky. The species taken, dates of collection or months of occurrence, number for each species identified and localities in which the collections were made are given in the following paragraphs in the order stated. Either the name of the military establishment or the name of the town or city in which the military establishment was located is given to indicate the locality.

[1] Colonel, MSC, Sixth Army Area Medical Laboratory, Fort Baker, California.

These names are abbreviated as follows: Camp Breckenridge: CB; Camp Campbell: CC; Danville: D; Fort Knox: FK; Lexington: L; Fort Thomas: FT.

Culex pipiens Linnaeus and *C. quinquefasciatus* Say are not included since it is not known whether identifications were based on examinations of male genitalia. However, the two species are known to comprise a major portion of the mosquito problem during the summer and early fall months.

Collection Records

Anopheles barberi, June, July, Aug., (6), CC; *An. crucians,* May, (2), CC; *An. punctipennis,* May–Sept., (574), CB, CC, D, FK; *An. quadrimaculatus,* May–Oct., (297), CB, CC, D, FK.

Toxorhynchites r. septentrionalis, Oct. 2, 1944, (3), CC.

Uranotaenia sapphirina, July, Sept., (2), CC, FK.

Culiseta inornata, May, (2), FK.

Orthopodomyia signifera, June, Aug., Oct., (38), CC, FK.

Mansonia perturbans, July 25, 1945, (1), CC.

Psorophora ciliata, July, Sept., Oct., (8), CC, FK; *P. cyanescens,* June–Oct., (208), CC; *P. ferox,* June, July, (7), CC; *P. horrida,* June 5, 1945, (1), CC; *P. confinnis,* July, Sept., Oct., (25), CB, CC, FK; *P. discolor,* May, July–Oct., (52), CC, FK.

Aedes canadensis, May, June, (26), CC, FK; *A. sticticus,* May, June, (12), CC; *A. triseriatus,* May–Oct., (121), CC, FK; *A. vexans,* Apr.–Oct., (163), CB, CC, FK, FT.

Culex restuans, Apr.–Oct., (535), CB, CC, D, FK, L; *C. salinarius,* Jan., May–Oct., (198), CC, D, FK; *C. tarsalis,* Sept., Oct., (4), CC, FK; *C. erraticus,* June–Oct., (72), CC, FK; *C. territans,* May–July, Sept., Oct., (62), CB, CC, FK.

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THE STIRRUP-SHAPED PIECE AS AN AID IN THE TAXONOMIC STUDY OF MOSQUITO LARVAE *

OSMOND P. BRELAND

University of Texas

The presence of a sclerotised structure, called the stirrup-shaped piece, in the siphon or air tube of mosquito larvae has been known for a long time (Howard, Dyar and Knab, 1912). Marshall (1938) states that the stirrup-shaped piece articulates with the inner flaps of the five valves at the distal end of the siphon. This structure is reported to be movable, and the direction of movement is supposed to determine the positions assumed by the valves. Distal movements of the stirrup-shaped piece causes the valves to diverge from each other, and to form a star-shaped figure. These valves, by adhering to the

* Supported by The University of Texas Research Institute. Drawings by Mrs. Grace Hewitt Groce.

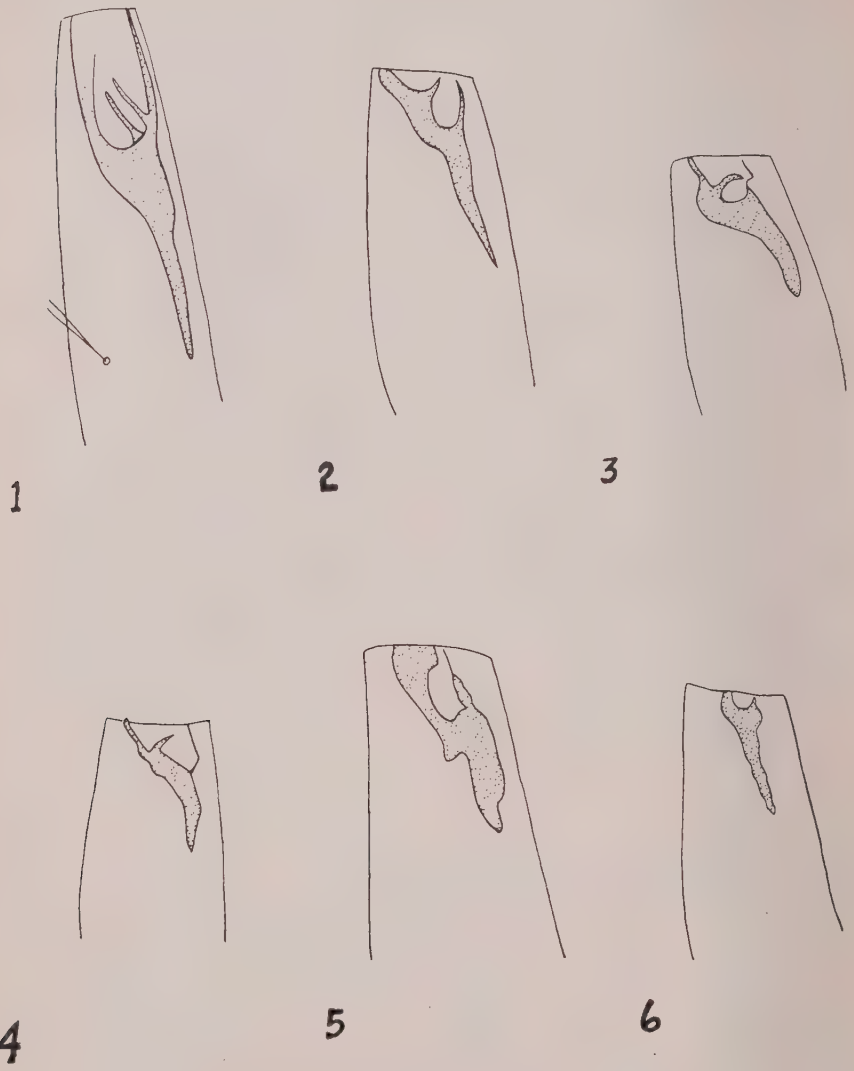

PLATE 1

Sketches of the distal end of the siphons of several species of mosquito larvae showing general shape of the stirrup-shaped piece. Sketches were made from permanent slides. The ventral surfaces of the siphons are to the reader's left. Valves and tracheae have been omitted. Fig 1, *Culex thriambus* Dyar. Fig. 2, *Uranotaenia syntheta* Dyar & Shannon. Fig. 3, *Aedes zoosophus* Dyar & Knab. Fig. 4, *Culiseta inornata* Williston. Fig. 5, *Psorophora howardii* Coquillett. Fig. 6, *Orthopodomyia alba* Baker.

surface film, help to maintain the larva at the water surface. When the larva dives, the stirrup-shaped piece is moved proximally. This movement in turn causes the valves to fold together over the end of the siphon (Marshall, 1938; Natvig, 1948).

So far as could be determined, the stirrup-shaped piece has not been used to any great extent by workers in mosquito larval taxonomy. The writer believes, however, that this structure should be given careful attention in all taxonomic studies of culicine mosquito larvae. It appears likely that it will often prove to be a good supplementary taxonomic feature, and may in some cases, even be of prime importance. The following preliminary observations, with the accompanying sketches, are offered in support of these conclusions.

The stirrup-shaped piece is partially surrounded by the two tracheal tubes which extend to the distal end of the siphon. Since the siphon and tracheae are translucent, the general shape of the structure can usually be seen even in permanent larval holomounts. However, in such studies, details of structure cannot be determined with certainty. All the sketches (Plate I) were made from permanent slides, and this is the reason that no details are shown and the valves are omitted.

The possible importance of the stirrup-shaped piece first came to the writer's attention in a recent study of the larvae of *Culex thriambus* Dyar. This species has been considered to be a synonym of *C. stigmatosoma* Dyar, but was recently restored to specific rank (Galindo and Kelley, 1943). The stirrup-shaped piece of many species of *Culex* has been examined, including species considered to be closely related to *C. thriambus*. This structure is so outstanding in *C. thriambus* that it is believed the larvae can be determined from the stirrup-shaped piece alone. In no case, except *C. thriambus,* has the writer seen a stirrup-shaped piece with two elongate teeth attached to the dorsal side of its expanded portion (Fig. 1, Plate I).

In addition to possible significance in studies of fourth instar larvae, the stirrup-shaped piece may often be of value in distinguishing between instars. Mr. Robert A. Hedeen, a graduate student of the writer's, has found that the extent of development of the structure is one of the easiest methods of distinguishing between the second and third instars of certain species.

Sketches of the stirrup-shaped pieces of several species of mosquito larvae are reproduced in Plate I. Preliminary studies indicate that the general shape of this structure may have value in distinguishing between genera. Considerably more study and detailed dissections of the stirrup-shaped piece must be made, however, before its ultimate importance as a taxonomic feature can be determined with certainty.

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A PORTABLE MOSQUITO BAIT-TRAP[1, 2]

R. E. BELLAMY[3] AND W. C. REEVES

The successful operation of a mosquito stable-trap using carbon dioxide gas (dry ice source) as a bait has been described by Reeves (1951). To facilitate further studies, a small, portable bait-trap was developed[4] to supplement the larger stable-trap. This small trap shows much promise in capturing certain species of mosquitoes. Description of the trap and the results of preliminary testing in Kern County, California, during the summer of 1951 form the basis of this report.

DESCRIPTION OF THE TRAP AND TRAPPING METHODS. The trap (Fig. 1) is made from a standard 50-pound lard can (12 inches diameter x 14½ inches high). In constructing, a round hole 8¾ inches in diameter is cut in the center of both lid and bottom of the can. A funnel of 13¼ x 18 mesh bronze hardware cloth 10 inches in diameter and 5½ inches deep is fitted and soldered to the rim of each opening so that the apex of each funnel will be directed into the can. A ¾ inch diameter hole at the apex of each funnel permits the entrance of mosquitoes.

A block of dry ice, approximately 3 pounds, wrapped in heavy paper was used as a standard bait. A hole less than an inch in diameter was torn in the paper to permit the ready escape of gas. When such a bait was placed in a trap in the late afternoon, some ice usually remained the following morning.

The trap was operated either in a vertical or in a horizontal position. In the former, the bait block was suspended near the middle of the trap by a string or wire attached to the lid; in the latter, the bait was laid at the midpoint of the lower side of the can.

To remove mosquitoes, the trap, with funnel openings plugged, was placed inside a larger can with a wad of cotton wool soaked in chloroform. About 5 minutes sufficed to anesthetize the mosquitoes for removal from the trap.

Initial tests with one trap in late July, 1951, were sufficiently encouraging so that four additional units were constructed. The traps were tested on the ground and at various elevations up to at least 25 feet, suspended by cord from the limbs of trees or from convenient structures (Fig. 2). Most of the testing was done at a locality on Poso Creek, Kern County, California, an area selected because of the presence of a large population of *Culex tarsalis* Coq. On a few occasions the traps were tested at other localities in Kern County. Some special testing was done at the Poso Creek locality. In one instance, a baited trap was removed and replaced by another at various intervals throughout a night to provide data on the time that mosquitoes enter the traps. On another occasion, 100 mosquitoes were transferred by aspirator from a baited trap to an unbaited one about two hours after sunset; the unbaited trap was then left in an operating position until the following morning to determine what proportion of the mosquitoes would escape.

RESULTS. On five nights in August, 1951, all five traps were operated at the Poso Creek locality, the total catch of mosquitoes from the five traps being, 481, 1,146, 458, 573, and 1,302 on these respective nights. Of the 3,960 mosquitoes, 3,929 were *Culex tarsalis,* 11 males and the rest females. The other specimens were: *Culex quinquefasciatus* Say, 30 females;

[1] A contribution from the George Williams Hooper Foundation for Medical Research, University of California Medical Center, San Francisco, California, in cooperation with the Communicable Disease Center, Public Health Service, Federal Security Agency.

[2] This investigation was supported in part by a research grant from the Division of Research Grants and Fellowships, National Institutes of Health, Public Health Service.

[3] Scientist, Communicable Disease Center, Public Health Service, Federal Security Agency, Atlanta, Georgia.

[4] The authors are indebted to Gordon F. Smith and Vernon Hogue of the Kern Mosquito Abatement District, Bakersfield, California, for assisting with the construction and testing of an early trap.

and *Culex stigmatosoma* Dyar, 1 female. No trap failed to catch mosquitoes on any of these nights, the smallest number taken by a trap in a night being 8, and the largest number 551. (In July, when only one trap was used, negative trapping nights were experienced twice.) On the night of September 20 at the same locality 922 female *Culex tarsalis* and 25 female *Culex quinquefasciatus* were taken in a trap baited with an unusually large (about 5 pounds) block of dry ice.

On the few nights in August and September that the traps were operated at other localities in Kern County, some mosquitoes were taken each night but the catches were small, the total catch of the five traps not exceeding 100 specimens on any night. At one locality, the composition of the catch was unlike that from Poso Creek, 15 females of *Aedes nigromaculis* (Ludlow), 5 of *Aedes dorsalis* (Meigen), and 11 of *Culex tarsalis,* constituting the catch of a trap operated in a horizontal position on the ground.

On the one night that the time of entrance of mosquitoes was tested, *Culex tarsalis* entered the trap throughout the night, but there was a peak of activity at sundown and a lesser one at dawn.

Of the 100 mosquitoes left overnight in an unbaited trap, 95 were recovered the following morning.

In the quest of optimum operating conditions, the traps were shifted from one location to another, or were operated at different heights, or in different positions on successive trapping nights; therefore, the various trials are not comparable. However, the trapping experience supports the following pertinent points. With only rare exceptions, the specimens trapped were unengorged females which show little or no evidence of ovarian development.

The exact location of a trap greatly

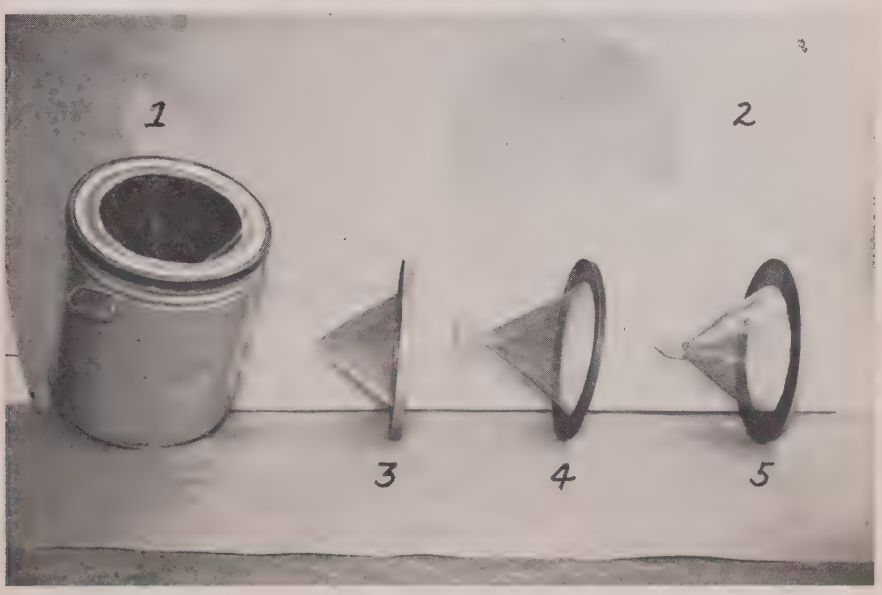

Figure 1. Lard Can Mosquito Trap

1. Assembled trap.
2. Screen cone pattern.
3, 4, and 5. Lids with screen cones or funnels soldered in place; 4 and 5, respectively, with angled and curved funnel opening extensions.
Funnel in bottom of can (1) does not show.

influences the catch. Apparently, a difference of a few yards in locating a trap would determine whether the catch would consist of several hundred specimens or of less than a dozen.

Culex tarsalis will enter a baited trap at almost any height from ground level up to at least 25 feet (some of the larger catches were from traps operated at heights of 14 or more feet).

FIGURE 2. TRAPS IN OPERATING POSITIONS

Note traps suspended vertically in tree (upper left and lower right), and traps suspended horizontally from tree limb (lower left) and from stakes just a few inches off ground.

When a trap is operated in a vertical position, *Culex tarsalis* will enter from below or (apparently less readily) from above. Most of the trials were with traps operated in a vertical position, suspended five feet above the ground or higher. The entrance hole of the top funnel was usually plugged when a trap was used in this manner, and in these instances a flat piece of screen could just as well have been substituted for the top funnel. The traps appeared to be only slightly more effective when suspended in a horizontal position with both funnels open. Operation of the traps on the ground is often unsatisfactory because ants enter and destroy the captured specimens.

SUMMARY AND CONCLUSION. The construction of a portable mosquito bait-trap from hardware cloth and a standard 50 pound lard can is described. This trap, when used with dry ice (carbon dioxide) bait, has shown much promise as a device for capturing adult female mosquitoes. The catches of *Culex tarsalis,* in particular, were large when the trap was operated in an area in Kern County, California, where this species was abundant. The other species collected were *Culex quinquefasciatus, Culex stigmatosoma, Aedes nigromaculis,* and *Aedes dorsalis.*

The trap is economically and simply constructed, is light and easily transported, and therefore offers a wide variety of possibilities in the positions and places in which it may be operated. In preliminary trials it is desirable to utilize several traps simultaneously at a locality in order to discover favorable operating sites promptly.

It would be interesting to observe the response of other species of mosquitoes to the trap and its efficacy in other areas.

Literature Cited

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ASSOCIATION NEWS

Tentative Schedule of the Joint Meeting of the American Mosquito Control Association and the Florida Anti-Mosquito Association to be Held at the Sheraton Plaza Hotel, Daytona Beach, Florida, April 12–17, 1953

Sunday, April 12

Those individuals expecting to visit St. Augustine and Marineland may receive Greyhound bus accommodations in Jacksonville every odd hour Sunday morning which will take them to St. Augustine. Bus accommodations can be obtained in St. Augustine that will take them to Marineland for the 2:00 P.M. show.

3:00–5:00	Registration—Sheraton Plaza Hotel, Daytona Beach.
5:00–7:00	Cocktail and Hospitality Hour (Courtesy Florida Anti-Mosquito Association and Mosquito Control Districts—Sheraton Plaza Hotel).

Monday, April 13

8–9:00	Registration.
9:00	Invocation and Address of Welcome.
9:15	Presidential Address: President V. Samuel Minnich, Florida Anti-Mosquito Association.
10:00–1:00	Reports from Florida Anti-Mosquito Districts.
2:30 P.M.	Opening session of the American Mosquito Control Association.
7:00	Sheraton Plaza Hotel Grounds—Fish Fry. (Courtesy Volusia County Anti-Mosquito District and Daytona Beach Chamber of Commerce.)

Tuesday, April 14

9–12	Program of the American Mosquito Control Association.
1:30–4:30	Program of the American Mosquito Control Association.
7:00–10:00 P.M.	Evening open. Night session if desired.

Wednesday, April 15

8:00	President's Breakfast of the American and Florida Anti-Mosquito Associations.
9–10	Program of the American Mosquito Control Association.
10–11	Business meeting of the Florida Anti-Mosquito Association.
11–1 P.M.	Business meeting of the American Mosquito Control Association.
2–5	Advertisers' demonstration of equipment on Hotel grounds.
7–8	Hospitality and Cocktail Hour. (Courtesy Florida Anti-Mosquito Association and the Mosquito Control Districts.)
8:00	Annual banquet.
10:00	Informal Dance—Sheraton Plaza Hotel.

Thursday, April 16

8:30–9:30	Time set aside for special meetings.
9:30	Leave for Silver Springs, caravan of cars.

12 NOON — Lunch at Silver Springs. Any individuals that desire to leave after a visit to Silver Springs may catch fast trains, busses or planes at Ocala. Spend night at Howie-in-the-Hills.

Friday, April 17

8:00 — Visit Citrus Packing, Canning and Concentrate Plant.
12 NOON — Lunch at Cypress Gardens. Visit Gardens and take in water show.
2:30 — Leave for Bok Tower. All those desiring to leave Friday evening may go directly to Tampa with part of caravan where fast trains, busses and large planes can be boarded for the west or east. Part of the caravan will continue south and spend Friday night in Sebring.

Saturday, April 18

Caravan will continue through the citrus, Lake Okeechobee cattle region, sugar cane and vegetable growing areas, and will approach the east coast at Palm Beach and continue to Miami with expectations to leave there in the early afternoon, so anyone desiring to leave Miami Saturday night by plane or train may make prior reservations.

Invitations to visit the laboratories of the Communicable Disease Center of the U. S. Public Health Service, Savannah, Georgia, and the Bureau of Entomology and Plant Quarantine's laboratory at Orlando, Florida, have been received by the program committee. Conducted tours will include these laboratories and other places of interest between Washington, D. C., and Daytona Beach, Florida. If you are interested in joining a cavalcade at any particular point, please notify F. C. Bishopp, Bureau of Entomology and Plant Quarantine, Washington 25, D. C., as soon as possible.

Instructions on how to reach these laboratories and other places of interest will be furnished if you wish to make the journey unattended.

NEWS AND NOTES

Koichi Onishi. Koichi Onishi died on October 27, 1952, at the age of 30, as a result of a coronary occlusion. Born in Garfield, Utah, he attended public school there, and later the University of Utah, before entering the U.S.A. 442nd Inf. Reg., where he saw service in Italy. Prior to coming to California in 1950, he studied under Prof. Don M. Rees and received the M.S. degree for his research on the mating habits of *Culiseta inornata*. He was a candidate for the degree of Doctor of Philosophy at the University of California. His interest included membership in the A.M.C.A. and he was active in the C.M.C.A. As Assistant Entomologist during the past three summers to the Alameda County Mosquito Abatement District, he participated in salt marsh mosquito biology and toxicity studies. He was well known and admired by his associates in the vector control field and especially by the workers in the San Francisco Bay area.

Surviving him are his wife, Nobie I. Onishi, and young son Erick Ko. His passing is a great personal loss, and is a loss of a scientific heritage, in that much of the best in teaching and association was characteristic of his professional and individual make-up. Theodore Aarons

The American Broadcasting Company's Television Program, All Star Review, on December 7 featured a report on some of the new antimalarial drugs. A motion picture, which was made in the Tropical Diseases Laboratory of the National Institutes of Health at Bethesda, showed how mosquitoes are used in the experimental transmission of malaria. Miss Helen Louise Trembley and Miss Dinniemaud Jensen were shown in their laboratory allowing mosquitoes to feed and engorge and making dissections of salivary glands. This was probably the debut of sporozoites on television. The program was narrated by Martin Agronsky.

John M. Henderson, until recently Professor of Sanitary Science in the Columbia University School of Public Health, has been appointed a Consultant to the Vector Control and Investigations Branch of the Communicable Disease Center, Public Health Service, Federal Security Agency. Since 1946 Mr. Henderson has been Professor of Sanitary Science in the Columbia School of Public Health, New York City. Concurrently, numerous special assignments in sanitation, irrigation, malaria control and other public health problems have taken him overseas. He served with an oil company in London and the Persian Gulf, with the World Health Organization and the Governments of India and Thailand, and as a visiting lecturer in schools of public health in Argentina, Brazil and Chile. In 1951–52 he was a member of a mission to the Venezuelan Government on the development of a public health program.

Mr. Henderson, who holds the rank of Sanitary Engineer Director (Colonel) in the commissioned reserve corps of the Public Health Service, is a Fellow of the American Public Health Assn., and a member of the American Mosquito Control Assn., the American Society of Civil Engineers, the American Society of Tropical Medicine and Hygiene, and the Inter-American Association of Sanitary Engineering.

Dr. F. Earle Lyman, a U. S. Public Health Service scientist who was with the Communicable Disease Center for several years, recently left the Service to accept an appointment as Associate Professor of Zoology at Southern Illinois University, Carbondale, Illinois.

A. Ralph Barr, who recently received the degree of Doctor of Science from the Johns Hopkins School of Hygiene and Public Health, is now on the staff of the Division of Entomology and Economic Zoology of the University of Minnesota.

L. A. Jachowski, Jr., Naval Medical Research Institute, Bethesda, Md., was the recipient of the Bailey K. Ashford Award for his work on the epidemiology of filariasis. The presentation was made at the first annual meeting of the American Society of Tropical Medicine and Hygiene at Galveston, Texas, on November 14, 1952. There were many AMCA members participating in the meeting. Dr. Martin D. Young selected as the title of his presidential address, "Malaria During the Last Decade."

A Feature of the Twenty-fourth Annual Meeting of the Eastern Branch of the American Association of Economic Entomologists at Baltimore in November was a symposium on Insect Resistance to Chemicals. Dr. F. C. Bishopp served as moderator. It was brought out that the question of resistance is extremely complex. It is the opinion of those who have done a great deal of fundamental work that greater emphasis must be placed on physical and naturalistic methods of control.

At the same meeting D. M. Jobbins reported on some experimental work in the use of granular dust formulations as mosquito larvicides. Indications are that some of these formulations have a promising future.

The Virginia Mosquito Control Association held its sixth annual meeting in Portsmouth, Va., on January 16, 1953. The program at the morning session was in the form of a "Stump-the-Experts" quiz during which questions on a wide variety of subjects were answered.

THE FIRST "CONFERENCE ON RELATIONSHIP OF AGRICULTURE AND MOSQUITO ABATEMENT" was held at the Davis Campus of the University of California, October 29 and 30. About 85 agricultural experts and mosquito abatement workers representing 30 MAD's signed the official register. Principal topics discussed were irrigation, drainage and problems connected with pastures, rice and cotton. A big step was taken toward better understanding of mutual problems. It is hoped that future meetings may even lead to joint efforts for solving these problems. *Mosquito Buzz*

MANY AMCA MEMBERS attended the sixty-fourth annual meeting of the American Association of Economic Entomologists at Philadelphia in December. Dr. Edward F. Knipling gave the presidential address, entitled "The Greater Hazard—Insects or Insecticides." Ten papers dealing with mosquitoes were presented before the Section on Medical Entomology which was presided over by Dr. A. W. A. Brown.

The Entomological Society of America met jointly with the American Association of Economic Entomologists, and arrangements for the consolidation of the two organizations were perfected. Several papers relating to mosquito physiology and taxonomy were presented at meetings of the Society. Among the authors were: Paul A. Woke, Dinniemaud V. Jensen, Jack Colvard Jones, Richard M. Bohart, and Osmond P. Breland.

THE YEARBOOK OF AGRICULTURE FOR 1952 is entitled "Insects." There are over 800 pages of text material with many illustrations including 72 beautifully executed colored plates. The book is not available from the Department of Agriculture but is for sale by the Superintendent of Documents. Senators and congressmen are allotted copies for free distribution to their constituents.

To Dr. F. C. Bishopp, chairman of the Yearbook Committee, much credit is due for the organization of the material and the wise selection of articles by outstanding workers. Most of the authors are employed by the Bureau of Entomology and Plant Quarantine, but there are many contributors of national prominence from other government agencies and from outside the federal service. Dr. Bishopp himself is the author of one article and the co-author of two more. As might be expected, each article is an accurate, up-to-date synthesis of scientific information on a given subject, but one is equally impressed with the high degree of readability which has been attained. People will enjoy reading this book. Insects and those whose business it is to combat insects will be more highly respected.

The fact that there are almost a hundred entries in the index under mosquitoes indicates the amount of attention they have received. Human diseases transmitted by mosquitoes are discussed briefly by Dr. Bishopp and Dr. C. B. Philip. Harry Stage in eight pages reviews taxonomy, biology, disease transmission and control. Of particular interest are the historical facts which have been recorded. Another worthwhile feature is the emphasis placed on the importance of bionomics in relation to control.

Over 130 pages are devoted to insecticides—their nature, methods of application, warnings as to their use, and resistance. Dr. W. V. King summarizes information on mosquitoes' resistance to DDT. Up to the present time the resistance problem with *Anopheles* is not severe.

Helen Sollers has an interesting article entitled "Entomologists in Washington" in which she mentions the importance of the work of Dr. L. O. Howard in the advancement of entomology, especially its medical aspects.

According to Frank H. Babers and John J. Pratt, Jr., in their chapter on Life Processes of Insects, the nature of the salivary gland secretions of mosquitoes is a mystery. In other words we do not know what makes mosquito bites itch.

PERRY W. RUTH. Word reached the NEWS just after it had gone to press that Perry W. Ruth had died of a heart attack in Norfolk, Virginia, on December 9, at the age of 76.

Perry, as he preferred to be called by all of his hundreds of friends in the AMCA, was a founder and past president of the Association. An appreciative account of his contributions to mosquito control work and of his unfailing zeal in promoting activities and organizations related to mosquito control is being prepared for the next number of MOSQUITO NEWS.

The 21st annual conference of the California Mosquito Control Association will be held on February 11, 12 and 13, 1953, at Sacramento, California.

The annual meeting of the New Jersey Mosquito Extermination Association will be held on March 4, 5, and 6, 1953, at the Hotel Haddon Hall, Atlantic City, N. J.

MOSQUITO NEWS FROM ALASKA*

Culiseta incidens (Thomson) Present in Southeastern Alaska. The collection of a single well-marked female (hibernator) of *Culiseta incidens* on May 29, 1952 and of two small larval samples, most probably of that species, the following month at Peterson Creek near Juneau confirms the occurrence of the mosquito in Alaska.

Since neither the intensive surveys of the Alaska Insect Project nor the *Culiseta* life-history studies of the Arctic Health Research Center recovered any *incidens* in the Upper Cook Inlet Area it has seemed prior to this finding prudent to question the recent Alaska records: (1) That of Stage and Chamberlin (this journal, 1945) for the Matanuska Valley based on specimens which were included in trap collections, very likely only rubbed *alaskaensis*; (2) That of Frohne (this Journal, 1951) for Ketchikan based on 21 larvae checked by Dr. Alan Stone but with the reservation: "It is possible these are *alaskaensis* larvae." *Incidens* appears to replace *alaskaensis* in Southeastern Alaska.

Water Level Predator of Emerging Mosquitoes. During June in Southeastern Alaska almost every breeding pool of *Aedes punctor* (Kby.) or *pionips* Dyar has its population of small smoky-winged flies tirelessly skimming the water surface. These are dance flies (Empididae), a species of *Rhamphomyia,* probably new, according to Dr. Willis Wirth of the U. S. National Museum, who kindly made the identification. It is reasonable to consider them important predators of the principal insects, viz. mosquitoes, of these pools, although not a great deal of their activities has been observed. Mosquito and midge pupae breaking the surface film are harried by the dance flies. Several midge pupae, which hatched in the shelter of the edge of the pool, were seized and carried off before their wings had hardened. When swatted, still-kicking mosquitoes were dropped on the water each was immediately found, grappled with, and soon carried away by these predators. This activity of the dance flies goes on for 18 or 20 hours a day in good weather, and since both sexes were collected skimming, it may be assumed both males and females are predaceous. Flying mosquitoes and other small insects in the air are ignored, but let one of them disturb the surface of the pool and dance flies are there in a flash.

This species of dance fly is not to be confused with another *Rhamphomyia* whose males prey on mating swarms of *Aedes punctor.* The predator of the water level is a smoky-winged fly very much like the swarm predator but is smaller and some of the spiny hairs of the legs and abdomen are yellow rather than black.

Alaskan Mosquitoes Disturb Snowshoers. Reporting to Juneau, Alaska, to start a mosquito survey in March 1952, I was embarrassed to find winter sportsmen enjoying several feet of accumulated snow. My early start did not surprise a group of public health specialists and enthusiastic snowshoers, however, who reported big mosquitoes had been landing on them and resting on the snow during February and March on the mountain ski trails. Inquiry of two fishery biologists making regular snowshoe trips throughout the winter elicited the further claim that they had seen mosquitoes during a warm spell sometime in January, as well as later on. I was able to collect the hibernators of *Culiseta impatiens* (Wlk.) in the area late in March, and it is presumed that this is the big mosquito the snowshoers saw. Mr. Frank Field, who was a malaria control engineer during the War, stated the insects were on the wing chiefly in the sunshine and when the air temperature was probably slightly above freezing. No one, evidently, was bitten.

* Contributed by William C. Frohne.

EDITORIAL

NEWS, VIEWS AND DUES

At the last previous annual meeting of the AMCA held in Salt Lake City, the Editor was requested to publish a revised membership list in an early number of MOSQUITO NEWS. We have been trying ever since to bring the list up to date.

Along with this never really completed task has gone a parallel effort to bring the dues and subscription payments up to date and the sad duty of dropping from the list the names of those too long delinquent.

Naturally, the latter operation is performed only after it is reasonably certain that the member is no longer interested, either through a definite statement from the person or agency involved, or after a reasonable length of time has passed without answers to inquiries.

There have been a number of instances, however, where it is known beyond reasonable doubt that a member is still interested; he contributes to MOSQUITO NEWS and attends meetings, but forgets to pay his dues.

In such instances we have not dropped the name from the list, because it is apparently only a case of oversight, but sooner or later we must have this action confirmed. There have also been instances where address changes have been originally entered as new subscriptions, especially where an agency or group was involved, because adequate information did not accompany the request for a change. Thus, for instance, a subscription entered under the name of a librarian might be renewed in the name of the library or laboratory with which the librarian was connected, with or without an address change. Unless specifically requested to replace one subscription with the other, the result might be two copies of the NEWS going to the same institution, one as to an old subscriber who had not paid dues but was given the benefit of the doubt, and one as to a new paid-up subscriber. This is not so unreasonable as it sounds when it is known, further, that some institutions actually do take out more than one subscription, and pay for them.

A further source of confusion is the fact that many an AMCA member seems to be of the roving kind, especially if he is in the armed forces. Thus he may not receive his NEWS promptly after an address change. Also, he may not receive dues notices either, and we temporarily lose touch with him.

The most recent list of members and subscribers was received in the editor's office on December 24, some time after the copy for the December number had been in the hands of the printer. Since it was too late to edit this for the printer and have it set without causing further delay in the December number, it was decided to save it for the March number.

In the meantime there is this one last opportunity for all of you who read this editorial, who have any reason to think that we do not have your latest address, to give complete information to the secretary or to the editor.

It is to the advantage of all concerned that immediate attention be given to this request.

REVIEWS AND ABSTRACTS

Mosquito Behaviour in Relation to Malaria Transmission and Control in the Tropics. Muirhead-Thomson, R. C. London. Edward Arnold & Co., 219 pp., 1951. This is a well-documented treatise by an author who has had more than ten years experience in observing and reporting on the behavior of Indian and African mosquitoes. Dr. Muirhead-Thomson has selected data from his previous papers and integrated them with information from the works of other authors. In the words of the writer, the book on mosquito behavior "is divided into two parts which are treated in rather different ways. In the first part, which is concerned with the movements of mosquitoes in relation to mating, feeding and resting we have been content to record and review the numerous more or less straightforward observations and experiments which have been made, without going too deeply into any analysis of the mosquitoes' complicated movements. In the second part, devoted to problems of the nature and selection of the breeding place, emphasis has been on the part played by simple physical and chemical factors in determining the behaviour of the female mosquito and of the immature stages."

The six chapter headings in Part I are: (1) General Activities in Relation to Mating, Feeding and Longevity; (2) Nocturnal Activity and Biting Cycles; (3) Outdoor Resting Places and the Exodus from Houses; (4) Host Selection; (5) Behaviour in Relation to Temperature, Humidity, and Light; and (6) Behaviour in Houses in Relation to Control by Insecticides. In Part II, the headings are: (7) Selection of the Breeding Place; (8) Light, Shade and Mechanical Obstruction; (9) Water Movement and Silt; (10) Water Temperature; (11) Dissolved Oxygen, Organic Matter and Pollution; and (12) Salt Water and Tidal Influence.—H. L. T.

The Present Status of Malaria in the World. Russell, P. F. Amer. Journ. Trop. Medicine Hyg. 1(1):111–123. 81 refs. 1952. Residual spraying with such toxicants as DDT has begun to change the status of malaria in the world. Already this new technique has almost eliminated malaria from many foci, including entire countries. Methods are fairly well standardized and can be applied on a nation-wide scale at financially feasible costs almost anywhere. But malaria is still probably the most prevalent serious illness of man and it should continue to receive major attention and high priority from those faced with the problems of international disease control. The greatest handicaps today in the control of malaria are lack of (a) trained personnel and (b) governmental antimalaria services within effective national health organizations.

Three major questions are currently being asked. First, will anopheline vectors become resistant to residual insecticides; second, is malaria control safe in holoendemic areas where the population has a strong tolerance to the disease; and third, is control worthwhile in areas which are or may be overpopulated?

Without presuming to answer them, one may comment on these questions briefly.

First, there is no clear record of practical anopheline resistance to an insecticide, but rumors are rife from Greece and Sardinia to the Tennessee Valley. Since both *Culex* and *Aedes* species, not to mention *Musca,* have become resistant, it seems reasonable to expect trouble and to think about counter-measures.

Second, the need for control is probably much greater in holoendemic areas than appears on the surface. If one is planning routine malaria control there is no logical reason to omit tolerant populations. Obviously, if one merely "tampers" with the situation, with no plans for continuity of effort, there could be epidemics after the community had lost its tolerance. However, modern drugs and sprays are so effective that, without gross neglect, serious ontbreaks are not likely.

Third, to this writer there appears to be no logical reason for slackening or stopping malaria control because of fears about increased populations pressure and concomitant evils. But, since our aim is a healthier world and not bigger populations, the need is apparent for an integration of malaria control activities with those of agriculturists, economists, educators, health officers and social scientists for the common good.—Author's conclusions.

Field Studies on the Comparative Effectiveness of D.D.T. and B.H.C. Against Mosquitoes When Applied Separately and in Combination. Singh, J.; Pal, R.; and Sharma, M. I. D. 1951. Indian Journ. Malariol. 5(2): 235–248. 1. Field trials on the comparative effectiveness of D.D.T. and B.H.C. against mosquitoes when applied separately and in combination are discussed. Studies were conducted in villages near Palwal, District Gurgaon, Punjab (I). 2. For proper evaluation of insecticides, more than one criterion has been applied concurrently so that results, as far as possible, can be correctly interpreted. Density of mosquitoes, window trap collections and percentage of survival of trapped mosquitoes after 24 hours, chemical estimation of insecticides from scrapings of treated surfaces, and malariometric data have been collected. 3. Irrespective of the dosage employed (50–200 mg. D.D.T. per sq. ft.) D.D.T. suspension was more effective than emulsion on mud-plastered walls. 4. Massive doses of D.D.T. when applied on mud-plastered walls whether as suspension or emulsion do not seem to show proportional increase in the duration of residual effect. After 12 weeks of application no D.D.T. could be detected even in the scrapings removed from the

houses treated with 200 mg. D.D.T. per sq. ft. 5. Under local conditions there is little to choose between D.D.T. 50 mg. (applied as suspension) and B.H.C. 10 mg. gamma isomer per sq. ft. Both give protection for about 6 weeks. Relative costs can decide the choice. 6. Both D.D.T. and B.H.C. exert a slight repellent effect on local species of mosquitoes but the insects pick up a lethal dose and eventually die. Control of malaria is effected by reduction in the density of mosquitoes and by the phenomenon of interception. 7. The additional effectiveness of D.D.T. and B.H.C. in combined spray (25 mg. D.D.T.+ 5 mg. B.H.C. gamma isomer/sq. ft.) was obvious. D.D.T. and B.H.C. combined spray was not only effective for a longer period but was also more efficacious in keeping down the density of mosquito population than either of them applied separately. 8. Choice of insecticides for malaria control is considered to depend upon the duration of the residual effectiveness and whether this effect is disturbed by human interference depending upon the habits and practices of inhabitants. Repeated application of D.D.T. and B.H.C. in combination at a dosage of 25 mg. D.D.T. and 5 mg. B.H.C. gamma isomer per sq. ft. at an interval of about 8 weeks is recommended.—Authors' summary and conclusions.

EFEITO DAS APLICAÇÕES INTRADOMICILIÁRIAS DE DDT SÔBRE A DENSIDADE DO *Anopheles darlingi* EM VÁRIAS REGIÕES DO BRASIL. De Bustamante, Fernando M. Rev. Brasileira Malariologia 3(4): 571–590. *Anopheles darlingi* is the most domestic species of the malaria vector mosquitoes in South America, coming into human dwellings in search of food in all districts where it is found. Despite the high degree of domesticity of this species throughout the area of its distribution, the frequency of its attacking man and animals outdoors varies widely. This frequency, which defines the index of zoophilism of the species, is in general much higher in Brazil than in Venezuela and British Guiana. In Brazil, the index of zoophilism of *A. darlingi* is higher in the central uplands than in the coastal lowlands. In consequence, the effect of DDT house spraying on the density of this species is highly variable. While in Venezuela and British Guiana this mosquito has been or is being eradicated from great areas where the only anti-mosquito work performed was biannual house spraying, in Brazil DDT did not produce the same result. *A. darlingi* is still being found in sprayed areas, on the coast and in the hinterland as well.

The possibility of eradication of *A. darlingi* seems to depend essentially on the tendency of this species to feed outdoors, the probability of eradication being inversely proportional to this tendency. Data presented by the author for the coastal lowlands of the state of Rio de Janeiro and the central uplands of the Sao Francisco river valley make possible the hope, after some indeterminate time, of the eradication of *A. darlingi* from coastal districts of the state of Rio de Janeiro. It is not probable, however, that the same result can be obtained in the central uplands, where, in spite of the spraying, *A. darlingi* continues to be caught either as adults (captured with animal bait) or as larvae.—Author's summary.

BIOLOGY AND CONTROL OF LABRADOR BLACK FLIES (DIPTERA: SIMULIIDAE). By B. Hocking and W. R. Richards. Bull. Entom. Res. 43(2): 237–257. 1952. 25 refs. Twenty-five species of Simuliidae are listed with indications of their relative abundance, importance as pests of men, seasonal appearance, temperature requirements, and larval habitats in Labrador. Seven of these are undescribed species. The most important species are *Simulium venustum* Say and *Prosimulium hirtipes* (Fries).

A circular area of 200 square miles around Goose Bay airport was surveyed for important breeding sites. Of 163 streams and rivers investigated, 77 were suitable as larval habitats, and larvae were virtually eliminated from them in June, 1950, by applications of a 10 per cent solution of DDT in fuel oil at the rate of 1.5 p.p.m. from a helicopter, conventional aircraft, or boats, or by hand application from the ground. Methods of application are discussed.

The repopulation of the area by black flies was studied, and deductions are made concerning the flight habits of the most important species. On the basis of averages throughout the season, a great reduction in numbers of black flies at the center of the area was obtained, and a worthwhile reduction to a distance of between 4 and 6 miles from the center. Even near the center of the area, however, black flies were sometimes troublesome late in the season.

It is suggested that, where *P. hirtipes* is the important species, relief for at least one season could be secured by eliminating larvae within a radius of 2 miles; for *S. venustum*, 6 miles is suggested as a suitable radius.

No adverse effects on useful animals were recorded.—Authors' summary.

FACTORS AFFECTING EVALUATION OF INSECTICIDES AGAINST *Anopheles* LARVAE. By Krusé, C. W., Ludvik, G. F., and Hawkins, W. B. J. Econ. Ent. 45(4):598–601. In this study on evaluation of laboratory tests with DDT against *Anopheles quadrimaculatus*, the authors observed that with the same dosage of DDT the average kill could be varied from 80 to 1.5 per cent just by increasing the numbers of larvae per given test. Although crowding of controls had no effect on mortality at 24 hours, in tests with DDT, crowding led to greater activity with the result that larvae came into greater contact with the toxicant. In such cases, however, the amount of available DDT per larva was apparently reduced.

One of the more interesting findings in this paper was that the Orlando *quadrimaculatus* strain was more susceptible to DDT than the Wilson Dam strain when they were added to test

solutions at the same time. No significant difference was found between DDT resistance of the Beaver Dam and Wilson Dam strains of *quadrimaculatus*.

The authors found definite losses of DDT from suspensions in glass, enamel, and paper testing containers. Twenty-five per cent of the DDT had "settled out" in 9 hours with glass or enamel containers. The same amount "settled out" in 2 hours in paper containers (ice cream cartons). At the end of 24 hours, they found that 60 per cent of the DDT was still in suspension in enamel, 57 per cent in glass, and only 24 per cent in paper containers.

Emulsions of DDT remained completely dispersed in both glass and enamel containers, but there was a loss of 21 per cent of DDT in paper containers after 24 and 48 hours.

There is no discussion of the causes of the adverse "settling out" effects of paper containers on DDT. Perhaps, it is possible that the waxy character of the paper cartons has something to do with this effect.—Jack Colvard Jones.

Factors Influencing the Performance of the Precipitin Test in the Determination of Blood Meals in Insects. By G. S. Eligh. Canad. J. Zool. 30(4):213–218. 1952. Description of a new method of preparing blood-engorged mosquitoes for determination (by the precipitin "ring-test" method) of the kind of animal fed upon. Entire specimens of blood-engorged *Aedes aegypti* were vigorously smeared on high quality filter paper (Stanscien 333) with thumb and forefinger pressure. Smears were dried and stored. When extracted with saline solution for tests, such preparations were found to be superior to those in which only the dissected gut contents were used. A technique is described for detection of partially digested blood in mosquitoes.—Jack Colvard Jones.

Dispersal of DDT from Aircraft for Mosquito Control. I. M. Mackerras, F. N. Ratcliffe, D. Gilmour, and M. W. Mules. Bulletin No. 257, Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia, 64 pages. Although just received (August 1952) this valuable bulletin is dated 1950. It contains the results of a number of air-spraying experiments from low-flying aircraft employed during the latter part of the war for mosquito and, to a lesser extent, for fly control. The technique and equipment developed by scientists of the Australian Army and Air Force during 1944 and 1945 provided a starting point for the air-spraying program organized by the Department of Agriculture in Victoria and herein reported. The importance of weather conditions on the effectiveness of spraying is also discussed. Treatments using as little as 1.9 imperial quarts per acre resulted in high mortality of adults and larvae and a residual effect for 7 to 8 days. The technique developed was used widely by the Australian Forces in New Guinea, Bougainville, and Borneo with valuable results in reducing populations of disease-carrying insects.—H. H. Stage.

Distribución Geográfica y Datos Bionómicos de los Anofelinos de Venezuela. By Pablo Cova-Garcia. 1951. Publicaciones de la Division de Malariologia, Número 10, Ministerio de Sanidad y Asistencia Social, Caracas, Venezuela, 226 pp. (Spanish.) Although dated 1951, the volume was not received by us until September 1952. Dr. Cova-Garcia has accomplished the enormous task of supplying information on the distribution and ecology of the known Anophelines in Venezuela, viz., *albimanus, oswaldoi, rangeli, triannulatus davisi, strodei, argyritarsis, darlingi, pessoai, albitarsis, pseudopunctipennis, eiseni, apicimacula, punctimacula, neomaculipalpus, peryassui, mattogrossensis, kompi, nimbus,* and *C. bathanus*. The author has analyzed the ecological data obtained over a period of 8 years in all parts of Venezuela. It is stated, for example, that *albimanus* breeds only in places exposed to sunlight, whereas *eiseni, nimbus,* and *C. bathanus* larvae were found only in heavy shade. *Albimanus* was shown to fly 2 kilometers whereas *darlingi* flew 5 kilometers.—H. H. Stage.

Please turn to page 259 for information of interest to all AMCA members.

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See also Symes under Adulticides.

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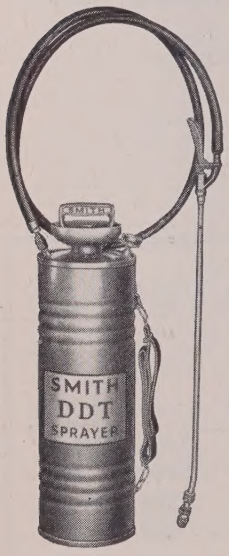

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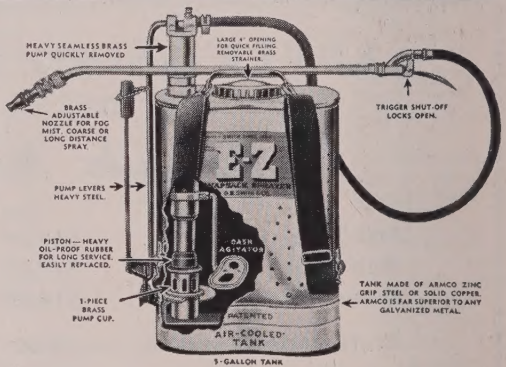
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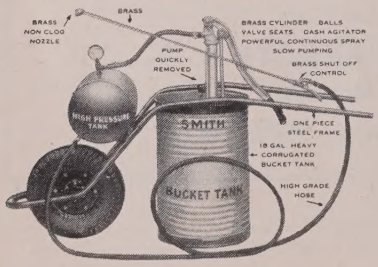

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